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GEOCHEMICAL INVESTIGATION OF COPPER MINERALISATION AT LOLUAI, (SULOGA PENINSULA, WOODLARK ISLAND, PAPUA).

by

A.G. Fricker and D.S. Trail.

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SUMMARY

Woodlark Island is located about 170 miles north east of Samarai, at the eastern tip of Papua.

During 1960, a geochemical investigation was made of an area of copper-iron mineralisation at Loluai on the south west coast of the Suloga Peninsula, a large promontory on the south coast of Woodlark Island.

Some copper ore was shipped from these deposits early in the century and again in 1957. Samples of creek sediments, from bottom and bank, and of creek waters gave inconclusive results, even in the vicinity of an ore-body. Local rainfall is high, and creeks are short with steep grades and only coarse sediments in their beds.

The copper anomaly coincides with the outcrop of a body of skarn rock developed in a group of interbedded volcanics and fine-grained sediments by contact metamorphism at the margin of a complex of gabbro sills. Dyke-like bodies of magnetite lie within the skarn outcrop.

Younger volcanic rocks are faulted against the skarn at its eastern boundary and boulders of volcanics mask the southerly continuation of the anomaly.

Soils were sampled by hand auger and analyses of trial samples from various levels revealed that 9 inches was a satisfactory and convenient depth for sampling.

The analytical method used for the prepared soils is specific for copper and is unaffected by temperature and humidity; a contour map of anomalous copper concentrations was drawn with a background value of 105 p.p.m.

Two areas of anomalous copper values were found. Large anomalies occupy a spur trending north-north-west uphill from the old workings at Loluai; concentrations up to 4,500 p.p.m. occur in the areas of high anomalous values. The east and west boundaries are well-defined, but the southern extension towards the coast is probably masked by boulders of volcanic rocks.

A small anomaly lies 650 yards east-north-east of Loluai and trends north-east along a spur. The maximum value of copper here is 1,800 p.p.m.

The threshold value for copper is taken to be between 600 and 700 p.p.m.

The copper mineralisation is distributed throughout the skarn but is only locally associated with the magnetite bodies. Copper concentration increases with depth and a zone of secondary enrichment may exist at the level of the water table.

The skarn body should be investigated by diamond drilling to locate and evaluate the zone of enrichment. Suitable sites exist in the areas of high copper anomalies.

INTRODUCTION

During the field season of 1960 a geochemical reconnaissance of creek waters, creek sediments, and soils was conducted over mineralised areas of Woodlark Island, Papua; included was a survey of the cupriferous magnetite outcrops that occur at Loluai on the Suloga Peninsula.

The outcrops were found in early exploration of Woodlark Island. Stanley (1917) records that ore, averaging 11% copper over a width of eighteen feet, with hand specimens averaging up to 48%, was shipped to Australia. R.C. Neate, who holds the current mining lease, has shipped ten tons of 10% ore to Japan in 1957.

Thomson (1960) described the geology of the area and the past mining history, as far as it is known. He mapped the outcrops and had grab samples from the mullock dump analysed. The samples analysed as follows:-

Samples	containing	'visibly high'	copper	contained	12.3% Cu and 55.8% Fe.
"	"	'obvious'	"	"	9.2% Cu and 49.4% Fe.
"	"	'no obvious'	"	"	0.67% Cu and 62.5% Fe.

Thomson concluded that there is a limited amount of selected ore averaging 10% of copper.

The initial creek water and creek sediment sampling was unsuccessful. However, soil sampling proved successful and the report deals mainly with this aspect of the work.

The prospecting team consisted of one chemist with native labour and occasional help from a field assistant. A total of 300 soil samples were collected and analysed in the six weeks spent at Loluai. Labour is the most expensive item, the cost of chemicals and apparatus being negligible; the cost of sampling and field analysis for copper was approximately 16/- per sample.

TOPOGRAPHY

Loluai is on the south-west coast of the Suloga peninsula of Woodlark Island. The peninsula consists of hilly country underlain by mineralised volcanic rocks and rises steeply from the sea to a maximum height of 1100 feet. At Loluai the coast runs easterly, as also does the main divide above Loluai; some 2500 feet to the north. In that distance the land rises to above 500 feet, giving an average gradient of 1 in 5. The stream systems are therefore short and steeply graded; they maintain a constant rapid flow throughout the year from a rainfall of 180 inches a year and have carved deep stream channels. The slopes are covered with primary jungle, with little secondary undergrowth.

GEOLOGY

The anomalous values of copper discovered by the investigation occur in the soil overlying a rectangular area of skarn rock which extends from the coast at Loluai to the watershed behind. The skarn is developed in a group of interbedded volcanics and fine-grained sediments by contact metamorphism at the margin of a complex of gabbro sills which extends north and west from Loluai.

The volcanics and fine-grained sediments are well exposed along the coast east and west of Loluai. The volcanic beds are composed of dark-grey lavas, pillow lavas, tuffs, and agglomerates with compositions varying between andesite and basalt, but predominantly augite-andesite. They are severely sheared and are cut by irregular veins of epidote and quartz. The textures of these rocks are obscured by metamorphism and they have a uniformly indurated appearance in hand specimen.

The fine-grained sediments, green, grey and red in colours are well-laminated siltstones and mudstones. The sediments are very siliceous and contain nodules and bands of chert. Iron-staining is common and some thin beds of fine sandstone contain ferruginous material.

North and west of Loluai the interbedded volcanics and sediments have been intruded by thick sills of medium-grained basic rock varying in composition between augite-diorite and gabbro. These sills have selectively and concordantly invaded and partly replaced the thick beds of volcanic rock. The relatively thin beds of sediment remain unaltered and continuous through the entire intrusive complex. Gabbro is exposed on the coast about one mile west of Loluai.

In the volcanic rocks immediately east and west of Loluai diorite dykes are common; the plagioclase is sodic and hornblende is the only dark mineral present in contrast to the diorites and gabbros of the sill complex which are augite-labradorite rocks.

The skarn rock developed at Loluai, and at Watavai Creek, lies at the south-east contact of the sill complex. The skarn is a friable reddish rock composed of coarse crystals of garnet with fine-grained epidote and some quartz and calcite; pyroxene is rare.

The skarn rock is presumably the result of the complete metasomatic alteration of limestone present in the sediments before silicification, (Magnusson, 1936). It is probable that the fine-grained sediments attained their present high proportion of silica as a result of the emplacement of the sill complex, and that originally they formed a group of normal shales, siltstones, and cherty limestones.

The magnetite bodies of Loluai have been described in detail by Thompson (1960). They are dyke-like features lying mainly within the skarn outcrop, and trending about 170°, which is also the direction of the diorite dykes on the shore near Loluai.

The magnetite bodies with associated quartz, pyrite, and copper minerals, are probably concentrations of hydrothermal solutions released by the gabbro as are the copper minerals distributed throughout the skarn rock.

The ridge forming the watershed north of Loluai is capped, to the east, by a group of volcanic rocks which have not been affected by the intrusion of the sill complex and the subsequent mineralisation. These are dominantly blue-grey fine-grained andesitic tuffs with some agglomerates.

These later volcanics are separated from the skarn by a fault occupying upper Loluai Creek; this has produced a sharp cut-off in copper values at the creek. Large quantities of float, shed from the outcrop of the later volcanics, have been carried downhill to obscure the skarn outcrop around lower Loluai Creek. The low values recorded along traverse line CD are probably due to this cover of volcanic float, overlying the skarn. The copper mineralisation is probably continuous between traverse line AB and the mineralised exposures at the old workings on the coast.

The skarn at Loluai lies in the trough and along the west limb of a syncline in the volcanics and sediments; the structure is fractured along its axis by the fault noted in upper Loluai Creek. The west limb dips about 15° to the northeast and the syncline pitches about 15° ~~the~~ to the north.

GEOCHEMISTRY

Sampling Procedure

The area surveyed is shown in outline on Plate 1. Soils were sampled at various depths within the area and analysed for copper. Initially a traverse was made along the watershed to the north of the magnetite outcrops in an attempt to eliminate effects due to slope and soil creep in the interpretation of results. Soil samples were taken at 2,3,6 and 8 feet depths along this traverse to determine to soil horizon best suited to the rock.

The soil horizons varied in thickness, number, colour and texture dependent on the parent rocks. Three inches is the maximum thickness of the humus horizon, Ao; the topsoil, horizon A, was about one foot thick; the subsoil, horizon B, up to 3 feet thick, underlain by horizon C of decomposing bedrock.

The values obtained in each horizon over this watershed traverse were plotted as profiles, and these had roughly similar shapes indicating a region of high copper content at the northern end of the subsequently discovered anomaly. Equal suitability of horizon was also indicated in the traverses CD and AB, which were sampled at 1½ and 3 feet depths. Sampling at 9" depth was found satisfactory, and much more convenient than sampling at greater depth. Results from samples taken at this depth were used to contour the illustrated anomaly.

North of Loluai, survey lines previously cut by H. Ward (consulting geologist acting for Thiess Brothers Ltd.), were sampled and used as a skeleton grid. From this grid, traverse lines running eastwards across the slope were cut at 200 foot intervals by line of sight, as magnetite bodies affected the magnetic compass. Samples at 9 inch depth were taken at 50 foot intervals along the traverse lines.

This method produced a rough grid survey; a more accurate grid would have been more satisfactory, but would have taken longer to lay out.

The smaller anomaly to the east was not examined in sufficient detail. Around and between the anomalies samples were taken at roughly 300 feet intervals along traverses 600 feet apart; but it is unlikely that any significant anomaly, other than those located, exists in the area surveyed.

On sampling, a handful of soil, about 100g., was collected from a hole bored by a 4" steel hand auger. The sample was well mixed, a portion was oven dried and gently crushed to break up aggregates and soft lumps; pieces of rock were not crushed. The sample was shaken on a stainless steel screen to reject rock fragments, and the -80 mesh fraction taken for analysis.

Analytical Procedure

The analysis used for the determination of copper in the soils was that employed by the geochemical prospecting section of the United States Geological Survey (1953). The sample is fused with potassium bisulphate and the melt taken up in dilute hydrochloric acid. After the insoluble material has settled, a suitable aliquot is taken and the copper determined by the purple complex formed with 2:2' - biquinolyl (cuproine) after extraction from a tartrate - acetate buffer with iso-amyl alcohols. An estimation of the copper content is made by visual comparison against a range of standards.

This method is specific for copper and cobalt. Cobalt provides a green complex, cupric ions an orange complex, and cuprous ions a purple complex. The cuprous ion is formed under the reducing influence of hydroxylamine in the test. The purple complex is not affected by time, sunlight, heat or oxidation by air and the method is ideal in all climates. Although ferric iron forms no coloured complex with cuproine it interferes by depressing transmission. This interference is to some extent overcome by the use of hydroxylamine which partially reduces the ferric to the non-interfering ferrous iron. The method is reproducible to ± 15%.

Results of soil sampling

The anylytical results are shown as a distribution pattern on the plan, Plate I.

105 p.p.m. was taken as the background value; this is an arbitrary figure selected by averaging all low, obviously non-anomalous values. A range of contour intervals ascending in geometric progression was chosen, so that the arithmetic mean of any one interval is a multiple of the background value, and differs from the mean of the adjacent intervals by a factor of two. The geometric reduction of analytical results suits the natural log-normal distribution of this type of data and the exponential nature of the visual comparison techniques, and ensures that the difference between two adjacent contour intervals is real.

The area of anomalous copper north of Loluai occupies a spur trending north-north-west up to the divide. The east and west boundaries of this area are sharp and follow the creeks defining the spur. This is illustrated by the values recorded along traverse A-B, at 1½ ft. and 3 ft. depths.

Table 1

A ——————————————————— B

Depth						
$1\frac{1}{2}$ ft.	630	5000	5000	7450	125	ppm. of cu.
3 ft.	470	2800	7000	7000	100	

The north boundary of the anomaly is ill-defined. South of the anomalous area, the low values recorded along traverse line C - D are due to a cover of boulders over the mineralised bedrock.

Table 2

C ——————————————————— D

Depth							
$1\frac{1}{2}$ ft.	200	250	700	800	125	150	ppm. of cu.
3 ft.	300	350	350	500	90	155	

Since copper mineralisation is obvious throughout the open-cut workings at Loluai and good grade ore has been mined there, the copper anomaly probably continues south below a cover of float, to the mining area.

In the anomalous area the highest values lie on a line close to the eastern boundary. Values above 3,000 p.p.m. are common along this line; the maximum value recorded is 4,500 p.p.m.

The smaller anomaly to the east trends north-east and is enclosed between branches of Watavai Creek. (Magnetite float here shows no copper.)

No samples were collected in the disturbed soil of the mining area, south of CD. The soil around the crescent-shaped outcrop crossing Loluai Creek is low in copper, ranging between 150 and 350 p.p.m.; there is no obvious copper in this outcrop. On the south-east spur of Lililoh Creek profuse magnetite float with no visible copper occurs, and again the soils are low in copper.

The value above which the metal is present in anomalous quantity, the threshold value, is between 600 and 700 p.p.m. The soils analysed were mostly well above or well below this value, since there is a sharp transition from background soil to anomalous soil.

Results of Creek water Examination

In this area of short steep slopes and heavy rainfall, the creeks run swiftly and continuously.

The heavy-metal content of the waters was determined by the method used by Huff (1948). The content ranged between 0.002 p.p.m. and 0.06 p.p.m., zinc being the main metal present. Copper was not once detected. The limit of detection in 0.002 p.p.m. and results between this value and 0.01 p.p.m. may be due to experimental error. Even at Loluai where the creek drains cupriferous soils no significant concentration of heavy metals was recorded. A small trickle of water from the adit half way up Loluai Creek on the west bank contained only 0.015 p.p.m. of heavy metals.

The pH values of the creek waters in this area are between 6.1 and 7. Iron and manganese staining are evident in the creeks. There is no copper staining although copper is precipitated under laboratory conditions at a pH greater than 4.7. At depth in the sulphide zone of the ore body copper solution occurs. The pH of the rising acid solutions will increase with dilution and chemical action, and thus the copper will be reprecipitated before the water enters the creeks.

Under conditions of relative drought when run off was much lower, the heavy metal content of the waters generally decreased. At any one sampling station, samples from the side or centre of the creek, whether still or running, showed no variation in base metal content.

Although the method is both sensitive and accurate it produced no significant results in the Loluai area.

The heavy metal concentrations showed no regular increase with distance upstream. Watavai Creek for example showed a decrease of concentration upstream, but streams generally showed fluctuations of metal content. The variation of metal content with distance would be extremely small, because the streams are short and swift-flowing and carry a large volume of water.

Results of Creek Sediment Examination

In the steep terrain round Loluai, fine-grained sediment is found only in the larger creeks, and is mixed with poorly-sorted gravel.

In view of the spasmodic occurrence of fine-grained sediment suitable for testing, creek bank soils were also sampled, on and below the water level. A 'high' reading from a bank soil may be due to anomalous amounts of heavy metal in the soil itself, or to heavy metal ions adsorbed from the waters.

The method of heavy-metal determination employed was that of Bloom (1955); carbon tetrachloride instead of xylene was used as a medium for the dithizinates.

The results, which are only relative, showed an irregular variation. Although fluctuations in metal content would be expected even in uniformly mineralised country, due to variations in constituency and absorpency from soil to soil, Bloom's method is probably practical only where a sediment or soil has a relatively very high base metal content. It produced no significant results in the Loluai area.

CONCLUSIONS AND RECOMMENDATIONS

The geochemical investigation has revealed that copper mineralization is not confined to the magnetite outcrops mapped by Thompson (1960), but is spread over the entire skarn outcrop. Magnetite boulders occur in all of the creeks shown on the map and magnetite float is spread over both anomalies and a large area on the spur south-east of Sililoi Creek; however, the only magnetite showing any evidence of copper mineralisation is that found in the vicinity of the outcropping lodes, at the foot of the steep slope at Loluai. In the magnetite body and in the surrounding skarn malachite veins are abundant and azurite is common.

This appearance of secondary copper mineralisation at the foot of the slope suggests that a zone of secondary enrichment may coincide with the surface of the water table, which would occur at some depth higher on the slope.

The skarn is poorly exposed and the low values of copper, along traverse line CD, are probably covered by a thin cover of volcanic float. Copper mineralisation is probably continuous from the anomalous area to the mineralised magnetite outcrops on the coast at Loluai.

It was generally found that the concentration of copper in the soil increased in depth, probably as the zone of secondary enrichment was approached. This zone of enrichment would be the target of the drilling investigation recommended, and it may coincide with the present-day level of the water table.

The skarn outcrop should be investigated by diamond drilling with a stationary split inner tube core barrel, as poor recovery may be expected in the friable rock.

The most suitable site for a first drill hole lies close to the small adit half way up Loluai Creek, at the centre of a high anomaly. A drillhole directed west from here and angled at 60° from the horizontal should traverse the skarn body and bottom in volcanics at about 300 feet. Poorly mineralized volcanics, igneous rocks, and sediments, will probably be found within the skarn, and drilling should not be discontinued on their account before target depth is reached.

Regardless of the results of this, other locations with high values should be investigated by vertical or steeply inclined holes. The extensions of the lodes visible in the old workings and in Loluai Creek might at the same time be investigated.

ACKNOWLEDGMENTS

We very gratefully acknowledge the unlimited hospitality and assistance accorded us by Mr. R.C. Neate, Mr. D.B. Neate, and their wives, the European residents on Woodlark. We derived much benefit from discussions in the field with Mr. H. Ward, consulting geologist acting for Thiess Brothers Limited.

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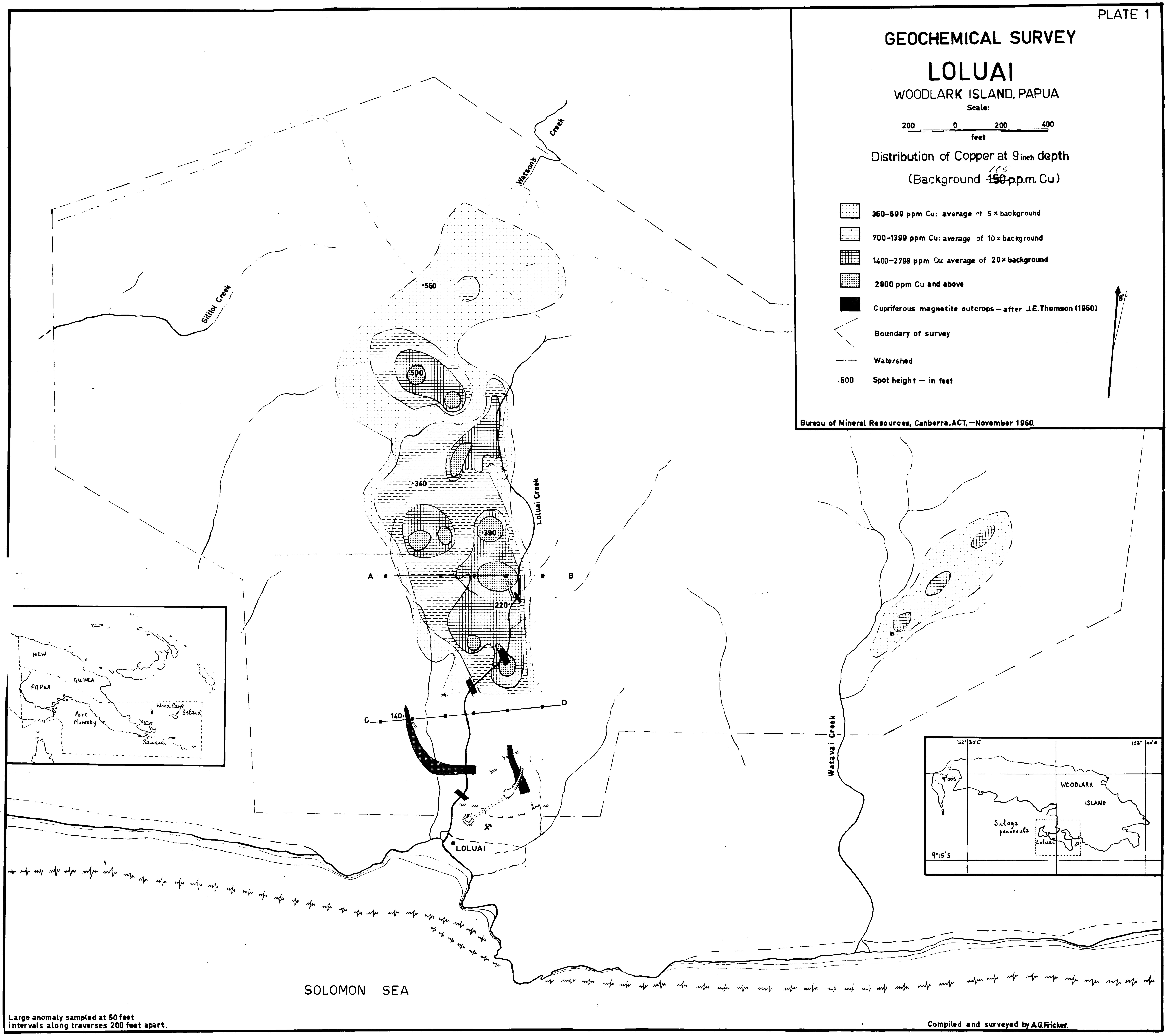
PLATE 1
GEOCHEMICAL SURVEY
LOLUAI
WOODLARK ISLAND, PAPUA
Scale:
200 0 200 400
feet
Distribution of Copper at 9 inch depth
(Background 165 150 p.p.m. Cu)
350-699 ppm Cu: average 5 × background
700-1399 ppm Cu: average of 10 × background
1400-2799 ppm Cu: average of 20 × background
2800 ppm Cu and above
Cupriferous magnetite outcrops — after J.E. Thomson (1960)
Boundary of survey
Watershed
.500 Spot height — in feet
Bureau of Mineral Resources, Canberra, ACT, — November 1960.
Watsons Creek
Sililoi Creek
Loluai Creek
Watavai Creek
.560
500
.340
.390
220.
140.
A
B
C
D
LOLUAI
SOLOMON SEA
NEW
GUINEA
PAPUA
Port Moresby
Woodlark Island
Samarai
152° 30'E
153° 00'E
9°00'S
9°15'S
WOODLARK
ISLAND
Suloga peninsula
Loluai
Large anomaly sampled at 50 feet intervals along traverses 200 feet apart.
Compiled and surveyed by A.G.Fricker.